

WE CLAIM:

1 1. A simultaneous vaporization and ionization spectrometry source,
2 comprising:
3 an electrically conductive conduit configured to receive particulate sample
4 carried by a carrier fluid stream, the conduit comprising a discharge end having an
5 opening configured to discharge the sample into a spectrometry analyzer; and
6 an electrically conductive reference device positioned proximate the
7 discharge end of the conduit at a distance therefrom sufficient to allow an electrical
8 potential to be established between the conduit and the reference device.

1 2. The simultaneous vaporization and ionization spectrometry source
2 of claim 1 wherein the distance between the conduit and the reference device is greater
3 than the Paschen distance.

1 3. The simultaneous vaporization and ionization spectrometry source
2 of claim 1 wherein the electrically conductive reference device is positioned proximate
3 the discharge end of the conduit such that the arrival of particulate sample proximate the
4 discharge end opening initiates a corona discharge at the discharge end of the conduit in
5 response to a sufficient electrical potential being maintained between the conduit and the
6 reference device.

1 4. The simultaneous vaporization and ionization spectrometry source of
2 claim 1 wherein the conduit is defined by an outer surface, and further comprising an
3 electrically non-conductive shield disposed about at least a portion of the conduit outer
4 surface.

1 5. The simultaneous vaporization and ionization spectrometry source of
2 claim 4 wherein the non-conductive shield is provided with an opening allowing an
3 electrical conductor to pass through said shield to contact the conduit.

1 6. The simultaneous vaporization and ionization spectrometry source of
2 claim 1 wherein the reference device comprises a metal selected from the group
3 consisting of stainless steel, platinum, and gold.

1 7. The simultaneous vaporization and ionization spectrometry source of
2 claim 1 further comprising an electrical circuit configured to establish and maintain an
3 electrical potential between the conduit and the reference device.

1 8. The simultaneous vaporization and ionization spectrometry source of
2 claim 7 wherein said electrical circuit comprises a voltage selector configured to allow
3 the electrical potential between the conduit and the reference device to be selectively
4 determined.

1 9. The simultaneous vaporization and ionization spectrometry source of
2 claim 7 wherein the electrical circuit is configured to maintain an electrical potential
3 between the conduit and the reference device of at least about 10 volts.

1 10. The simultaneous vaporization and ionization spectrometry source of
2 claim 7 wherein the electrical circuit is configured to maintain an electrical potential
between the conduit and the reference device of less than about 250 volts.

1 11. The simultaneous vaporization and ionization spectrometry source of
2 claim 1 wherein the conduit is electrically grounded.

1 12. The simultaneous vaporization and ionization spectrometry source of
2 claim 1 wherein the conduit comprises a hypodermic needle.

1 13. The simultaneous vaporization and ionization spectrometry source of
2 claim 1 wherein the reference device is ring-shaped and is positioned between the conduit
3 discharge end and the spectrometry analyzer.

1 14. The simultaneous vaporization and ionization spectrometry source of
2 claim 1 wherein the reference device comprises a grid comprising a plurality of openings
3 disposed therein to allow vaporized, ionized sample to pass from the discharge end of the
4 conduit into the spectrometry analyzer.

1 15. A spectrometer comprising:
2 a spectrometry analyzer; and
3 a simultaneous vaporization and ionization spectrometry source, the
4 source comprising:
5 an electrically conductive conduit configured to receive particulate
6 sample carried by a carrier fluid stream, the conduit comprising a discharge end having an
7 opening configured to discharge the sample into the spectrometry analyzer; and
8 an electrically conductive reference device positioned proximate
9 the discharge end of the conduit at a distance therefrom sufficient to allow an electrical
10 potential to be established between the conduit and the reference device.

1 16. The spectrometer of claim 15 wherein the distance between the conduit
2 and the reference device is greater than the Paschen distance.

1 17. The spectrometer of claim 15 wherein the electrically conductive reference
2 device is positioned proximate the discharge end of the conduit such that the arrival of
3 particulate sample proximate the discharge end opening initiates a corona discharge at the
4 discharge end of the conduit in response to a sufficient electrical potential being
5 maintained between the conduit and the reference device.

1 18. The spectrometer of claim 15 further comprising a control circuit
2 configured to generate pulses of electrical potential between the conduit and the

3 electrically conductive reference device sufficient to produce periodic electrical arcing
4 there between.

1 19. The spectrometer of claim 15 further comprising a control circuit
2 configured to generate an electrical potential between the conduit and the electrically
3 conductive reference sufficient to produce continuous electrical discharge there between.

1 20. The spectrometer of claim 15 wherein the spectrometry analyzer is
2 configured to analyze analyte ions in the form of vaporized, ionized sample based on
3 mass of vaporized analyte ions at atmospheric pressure.

1 21. The spectrometer of claim 15 wherein the spectrometry analyzer is
2 configured to analyze the analyte ions based on ion mobility of vaporized analyte ions.

1 22. The spectrometer of claim 15 further comprising a sample transport
2 system configured to transport the particulate sample to the discharge opening of the
3 conduit in a carrier fluid.

1 23. The spectrometer of claim 15 wherein the conductive reference device
2 comprises a sheathed conductive filament disposed within the conduit, and having an
3 unsheathed tip positioned proximate the discharge end of the conduit.

1 24. The spectrometer of claim 23 wherein the sheathed conductive filament
2 comprises an insulated wire.

1 25. The spectrometer of claim 15 wherein the conductive reference device
2 comprises a conductive probe disposed within the discharge end of the conduit.

1 26. The spectrometer of claim 15 further comprising a sweep gas system for
2 removing non-ionized particles from a region around the simultaneous vaporization and
3 ionization spectrometry source prior to the introduction of ionized particles into the
4 spectrometry analyzer.

1 27. The spectrometer of claim 15 further comprising an electrical circuit
2 configured to establish and maintain an electrical potential between the conduit and the
3 reference device.

1 28. The spectrometer of claim 27 wherein said electrical circuit comprises a
2 voltage selector configured to allow the electrical potential between the conduit and the
3 reference device to be selectively determined.

1 29. The spectrometer of claim 27 wherein the electrical circuit is configured to
2 maintain an electrical potential between the conduit and the reference device of at least
3 about 10 volts.

1 30. The spectrometer of claim 27 wherein the electrical circuit is configured to
2 maintain an electrical potential between the conduit and the reference device of less than
3 about 250 volts.

1 31. The spectrometer of claim 15 wherein the spectrometry analyzer
2 comprises an ion mobility spectrometry analyzer.

1 32. The spectrometer of claim 15 wherein the spectrometry analyzer
2 comprises an atmospheric pressure ionization mass spectrometry analyzer.

1 33. A method for simultaneous vaporization and ionization of particulate
2 sample to produce analyte ions for spectrometric analysis, comprising:
3 providing a particulate sample to be spectrometrically analyzed;
4 providing a first electrode;
5 providing a second electrode proximate the first electrode;
6 maintaining a first electrical potential at the first electrode, and a second
7 electrical potential at the second electrode, such that an electrical potential exists there
8 between;
9 providing a carrier fluid for transporting the particulate sample to a point
10 proximate the first and second electrodes;
11 transporting the particulate sample via the carrier fluid to a point
12 proximate to the first and second electrodes;

13 causing electrical arcing between the first and second electrodes at a time
14 when the particulate sample arrives thereat to cause at least partial vaporization and
15 ionization of the particulate sample to produce analyte ions.

1 34. The method of claim 33 wherein the electrical potential between the first
2 and second electrodes is maintained slightly above a breakdown potential there between,
3 and the electrical arcing between the first and second electrodes is caused by the presence
4 of the particulate sample thereat altering the breakdown potential, resulting in a corona
5 discharge causing at least partial vaporization and ionization of the particulate sample to
6 produce analyte ions.

1 35. The method of claim 33 wherein the electrical potential between the first
2 and second electrodes is maintained such as to produce a continuous arcing there
3 between, thereby causing continuous at least partial vaporization and ionization of the
4 particulate sample to produce analyte ions.

1 36. The method of claim 33 wherein the electrical potential between the first
2 and second electrodes is initially maintained at a level below a breakdown potential there
3 between, the method further comprising the step of periodically increasing the potential
4 between the first and second electrodes to cause periodic corona discharge thereat
5 resulting in at least partial vaporization and ionization of the particulate sample present at
6 the electrodes at the time of discharge, to produce analyte ions.

1 37. A method for simultaneous vaporization and ionization of particulate
2 sample to produce analyte ions for spectrometric analysis, comprising:
3 providing a particulate sample to be spectrometrically analyzed;
4 providing a first electrode;
5 providing a second electrode proximate the first electrode;
6 providing a carrier fluid for transporting the particulate sample to a point
7 proximate the first and second electrodes;
8 transporting the particulate sample via the carrier fluid to a point
9 proximate to the first and second electrodes;
10 maintaining a first electrical potential at the first electrode, and a second
11 electrical potential at the second electrode at a point above a breakdown potential there
12 between such that the arrival of the particulate sample at the point proximate to the first
13 electrode causes a corona discharge as a result of altering the breakdown potential, the
14 corona discharge causing at least partial vaporization and ionization of the particulate
15 sample to produce analyte ions.

1 38. The method of claim 33 wherein the carrier fluid is a gas.

1 39. The method of claim 33 further comprising the step of analyzing the
2 analyte ions using a spectrometry analyzer.

1 40. The method of claim 34 further comprising the step of adjusting at least
2 one of the first or the second potentials to cause a corona discharge in the absence of
3 particulate sample at the point proximate to the first and second electrodes, and then
4 altering the potential of at least one of the first or the second potentials to create an
5 equilibrium state between the first and second potentials where no corona discharge
6 occurs in the absence of particulate sample at the point proximate to the first and second
7 electrodes.

1 41. The method of claim 37 further comprising the step of adjusting at least
2 one of the first or the second potentials to cause a corona discharge in the absence of
3 analyte ions at the point proximate to the first electrode, and then increasing the potential
4 of at least one of the first or the second potentials to create a voltage potential difference
5 between the electrodes of between about 10 and 50 volts.

1 42. The method of claim 33 wherein the steps are performed within an ion
2 mobility spectrometer.

1 43. The method of claim 33 wherein the steps are performed within an
2 atmospheric pressure ionization mass spectrometer.